

CLAIMS

What is claimed is:

1. A multistage amplifier comprising:
an initial stage including a first input to receive an input signal, a second input to receive a combined feedback signal, and an output, and wherein the output of the initial stage provides an amplified signal responsive to the input signal;
a final stage including a first input coupled to the output of the initial stage and an output to provide a final output signal of the multistage amplifier, and wherein the final output signal is an amplified signal responsive to the input signal;
a first feedback loop coupling the output of the initial stage to the second input of the initial stage, and providing a first current-mode feedback signal to the second input of the initial stage;
a second feedback loop coupling the output of the final stage to the second input of the initial stage, and providing a second current-mode feedback signal to the second input of the initial stage; and
wherein the combined feedback signal is formed by combining the first and second current-mode feedback signals.
2. The multistage amplifier of claim 1, wherein the first feedback loop comprises a high pass filter, and the second feedback loop comprises a low pass filter.
3. The multistage amplifier of claim 2, wherein the high pass filter has a lower roll-off frequency, and the low pass filter has an upper roll-off frequency.

4. The multistage amplifier of claim 2, wherein the high pass and low pass filters comprise matched filter circuits such that a parallel combination of the high and low pass filters exhibits a desired impedance value across a signal frequency range of interest.
5. The multistage amplifier of claim 4, wherein the desired impedance value is a relatively constant value across the signal frequency range of interest.
6. The multistage amplifier of claim 5, wherein the desired impedance value varies across the signal frequency range of interest to compensate for non-uniformity in the frequency response of the multistage amplifier.
7. The multistage amplifier of claim 2, wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 20 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 10 MHz.
8. The multistage amplifier of claim 2, wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 60 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 30 MHz.
9. The multistage amplifier of claim 2, wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 120 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 60 MHz.
10. The multistage amplifier of claim 2, wherein the multistage amplifier exhibits frequency peaking at about 60 MHz, and wherein the high pass filter of the first feedback

loop exhibits a zero at about DC and a pole at about 60 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 50 MHz.

11. The multistage amplifier of claim 2, wherein the upper and lower roll-off frequencies, respectively, of the low and high pass filters are set relative to a desired crossover frequency.
12. The multistage amplifier of claim 11, wherein an amount of frequency overlap between the upper and lower roll-off frequencies controls attenuation of signal frequencies near the desired crossover frequency.
13. The multistage amplifier circuit of claim 2, wherein the high and low pass filters are configured such that the first feedback signal dominates the combined feedback signal at higher frequencies, while the second feedback signal dominates the combined feedback signal at lower frequencies.
14. The multistage amplifier circuit of claim 2, wherein the upper roll-off frequency of the low pass filter is below a critical frequency at which phase shift in the final output signal would cause amplifier instability if fed back to the initial stage.
15. The multistage amplifier of claim 1, wherein the multistage amplifier further comprises at least one intermediate stage coupling the output of the initial stage to the input of the final stage.
16. The multistage amplifier of claim 15, wherein the at least one intermediate stage comprises at least one buffer amplifier.

17. The multistage amplifier of claim 15, wherein the final stage comprises a MOSFET output stage.
18. The multistage amplifier of claim 17, wherein the at least one buffer amplifier isolates the initial stage from an input capacitance of the MOSFET output stage.
19. The multistage amplifier of claim 1, wherein the multistage amplifier is configured as a supply voltage amplifier in a radio frequency envelope-elimination-and-restoration (EER) circuit.
20. The multistage amplifier of claim 19, wherein the multistage amplifier receives an amplitude modulation signal as the input signal to the first input of the initial stage, and provides a voltage supply signal at the output of the final stage responsive to amplitude modulation information in the input signal.
21. The multistage amplifier of claim 1, further comprising at least one intermediate stage, and wherein the output of the initial stage is coupled to the first input of the final stage through the at least one intermediate stage.
22. The multistage amplifier of claim 1, further comprising a buffer amplifier stage coupling the output of the initial stage to the first input of the final stage, thereby buffering the initial stage from the final stage.
23. The multistage amplifier of claim 22, wherein the final stage comprises a MOSFET output stage, and wherein the buffer amplifier stage isolates the initial stage from a capacitive loading of the MOSFET output stage.

24. A radio base station for use in a communication network, the radio base station including at least one multistage amplifier using dual feedback for signal amplification, said multistage amplifier comprising:

an initial stage including a first input to receive an input signal, a second input to receive a combined feedback signal, and an output that provides an amplified signal that is responsive to the input signal;

a final stage including a first input coupled to the output of the initial stage and an output to provide a final output signal of the multistage amplifier that is responsive to the input signal applied to the initial stage;

a first feedback loop coupling the output of the initial stage to the second input of the initial stage, and providing a first current-mode feedback signal to the second input of the initial stage;

a second feedback loop coupling the output of the final stage to the second input of the initial stage, and providing a second current-mode feedback signal to the second terminal of the initial stage; and

wherein the combined feedback signal is formed by combining the first and second current-mode feedback signals.

25. The radio base station of claim 24, further comprising a radio frequency (RF) power amplifier including a RF signal input to receive an input signal and a supply voltage input coupled to the output of the final stage of one of the at least one multistage amplifiers, and wherein the RF power amplifier generates a RF output signal by amplifying the RF input signal.

26. The radio base station of claim 25, wherein the one multistage amplifier and the RF power amplifier comprise at least a portion of an envelope-elimination-and-restoration (EER) circuit, and wherein the final output signal of the one multistage amplifier serves as the supply voltage for the RF power amplifier, such that amplitude modulations in the final output signal impart amplitude modulations to the RF output signal.

27. The radio base station of claim 26, wherein the first input of the initial stage of the one multistage amplifier is coupled to an amplitude modulation signal representing desired amplitude modulation information, and further wherein the RF signal input of the RF power amplifier is coupled to a phase modulation signal representing desired phase modulation information, such that the RF output signal includes desired amplitude and phase modulation information.

28. The radio base station of claim 27, further comprising transmit processing resources generating the amplitude and phase modulation signals based on desired transmit information.

29. The radio base station of claim 26, further comprising a transmit antenna, and wherein the RF output signal from the RF power amplifier is transmitted via the transmit antenna.

30. The radio base station of claim 24, wherein the first feedback loop comprises a high pass filter, and the second feedback loop comprises a low pass filter.

31. The radio base station of claim 30, wherein the high pass filter has a lower roll-off frequency, and the low pass filter has an upper roll-off frequency.

32. The radio base station of claim 31, wherein the high pass and low pass filters comprise matched filter circuits such that a parallel combination of the high and low pass filters exhibits a desired impedance value across a signal frequency range of interest.

33. The radio base station of claim 32, wherein the desired impedance value is a relatively constant value across the signal frequency range of interest.

34. The radio base station of claim 33, wherein the desired impedance value varies across the signal frequency range of interest to compensate for non-uniformity in the frequency response of the multistage amplifier.

35. The radio base station of claim 30, wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 20 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 10 MHz.

36. The radio base station of claim 30, wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 60 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 30 MHz.

37. The radio base station of claim 30, wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 120 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 60 MHz.

38. The radio base station of claim 30, wherein the multistage amplifier exhibits frequency peaking at about 60 MHz, and wherein the high pass filter of the first feedback loop exhibits a zero at about DC and a pole at about 60 MHz, and further wherein the low pass filter of the second feedback loop exhibits a pole at about 50 MHz.

39. The radio base station of claim 30, wherein the upper and lower roll-off frequencies, respectively, of the low and high pass filters are set relative to a desired crossover frequency.

40. A method of improving the performance of a multistage amplifier having at least initial and final stages, the method comprising:

- deriving a current-mode first feedback signal from an output of the initial stage;
- deriving a current-mode second feedback signal from an output of the final stage;
- combining the first and second feedback signals to form a combined feedback signal; and
- applying the combined feedback signal to a feedback input of the initial stage.

41. The method of claim 40, wherein deriving the first feedback signal comprises closing a high-pass inner feedback loop from the output of the initial stage to the feedback input of the initial stage, and wherein deriving the second feedback signal comprises closing a low-pass outer feedback loop from the output of the final stage to the feedback input of the initial stage.

42. The method of claim 41, further comprising setting frequency responses for the inner and outer feedback loops such that a parallel impedance formed by the inner and outer feedback loops is substantially constant across a frequency range of interest.

43. The method of claim 41, further comprising tuning the frequency responses of the inner and outer feedback loops to compensate for a frequency response of the multistage amplifier.
44. The method of claim 43, further comprising setting a frequency crossover point between the inner and outer feedback loops to coincide with a frequency response peak of the multistage amplifier.
45. The method of claim 44, further comprising adjusting the frequency response roll-offs of the inner and outer loops at the frequency crossover point such that the frequency response peak of the multistage amplifier is attenuated.
46. The method of claim 41, further comprising setting the frequency responses of the inner and outer feedback loops such that an impedance of the parallel combination of loops effects pole-zero compensation of the multistage amplifier.
47. The method of claim 40, further comprising setting a frequency response of at least one of the first and second feedback signals to compensate for a frequency response of the multistage amplifier.
48. The method of claim 40, further comprising setting frequency responses for the first and second feedback signals such that a frequency crossover point between the frequency responses of the first and second feedback signals coincides with a frequency response peak of the multistage amplifier.

49. The method of claim 40, further comprising setting frequency responses for the first and second feedback signals to perform pole-zero frequency compensation of the multistage amplifier.

50. The method of claim 40, further comprising setting an upper roll-off frequency of the second feedback signal such that the second feedback signal substantially excludes signal frequencies beyond a critical frequency associated with stability of the multistage amplifier.

51. The method of claim 50, further comprising establishing the critical frequency to be no greater than a frequency at which the second feedback signal experiences phase shift sufficient to cause instability of the multistage amplifier.

52. The method of claim 40, further comprising tuning frequency responses of the first and second feedback signals such that the first feedback signal dominates the combined feedback signal at higher frequencies of a signal to be amplified by the multistage amplifier, and the second feedback signal dominates the combined feedback signal at lower frequencies of the signal to be amplified.

53. The method of claim 40, further comprising setting an upper frequency roll-off of the second feedback signal in combination with a lower frequency roll-off of the first feedback signal to achieve a desired multistage amplifier frequency response.

54. The method of claim 53, further comprising setting the upper frequency roll-off of the second feedback signal to be below a critical frequency at which feedback from the final stage to the initial stage would otherwise cause the instability in the multistage amplifier.

55. The method of claim 40, further comprising setting frequency responses for the first and second feedback signals to balance between loop-gain and phase margin of the multi-stage amplifier.